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Reconnaissance of the Hydrology, Water Quality, and Sources of Bacterial and Nutrient Contamination in the Ozark Plateaus Aquifer System and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999–March 2000

Water-Resources Investigations Report 00–4210

U.S. Department of the Interior
U.S. Geological Survey

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Mansour Samadpour, University of Washington

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Water Resources Division
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Conversion Factors and Datum

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi^2)	2.590	square kilometer (km^2)
Flow rate		
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$°F = (1.8 \times °C) + 32$

Vertical coordinate information is referenced to the North American Vertical Datum of 1998 (NAVD 88).

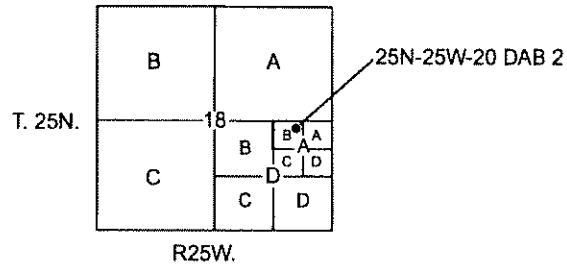
Horizontal coordinate information is referenced to the North American Datum of 1998 (NAD 88).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Local identifier: The locations of the wells are specified by latitude and longitude to the nearest second and by a local identifier, which is based on the public land survey. The local identifier includes the township and range followed by the section and a series of letters that designate the quarter-section subdivisions from largest to smallest. The order of the quarter-section subdivisions is opposite of that used by the public land survey. A sequence number is added to make the local identifier unique in the U.S. Geological Survey data base. As illustrated in the following diagram, the public land survey description of the site indicated by the dot is NW 1/4 NE 1/4 SE 1/4 sec. 20, T. 25 N., R. 25 W., which is denoted by the local identifier 08N-02W-18 DAB. If the sequence number is 2, the complete identifier is 25N-25W-20 DAB 2.



Reconnaissance of the Hydrology, Water Quality, and Sources of Bacterial and Nutrient Contamination in the Ozark Plateaus Aquifer System and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999-March 2000

By Jamie L. Schlottmann, Ralph S. Tanner, and Mansour Samadpour

Abstract

A reconnaissance investigation of hydrology and water quality was conducted to evaluate possible sources of bacteria and nutrient contamination in the Cave Springs Branch basin and the underlying karstic Ozark Plateau aquifer system. Objectives were to: (1) determine the directions of ground-water flow in the basin and determine whether Cave Springs Branch interacts with ground water, (2) compare water quality in Cave Springs Branch with water quality in nearby wells to determine whether the stream is contaminating nearby wells, and (3) determine sources of fecal coliform bacteria and nitrate contamination in Cave Springs Branch and ground water. Potential sources of bacteria and nitrate in the area include cultivated agriculture, cow and horse on pasture, poultry production, households, and wildlife. Presence of fecal coliform and fecal streptococcal bacteria directly indicate fecal contamination and the potential for the presence of other pathogenic organisms in a water supply. Nitrate in drinking water poses health risks and may indicate the presence of additional contaminants.

Fecal coliform bacteria colony counts were least in wells, intermediate in the poultry-processing plant wastewater outfall and Honey Creek above the confluence with Cave Springs Branch, and greatest in Cave Springs Branch. Bacteria strains and resistance to antibiotics by some bacteria indicate that livestock may have been sources of some bacteria in the water samples. Multiple antibiotic resistances were not present in the isolates from the water samples, indicating that the bacteria may not be from human or poultry sources.

Ribotyping indicates that *Escherichia coli* bacteria in water samples from the basin were from bird, cow, horse, dog, deer, and human sources. The presence of multiple ribotypes from each type of animal source except bird indicates that most of the bacteria are from multiple populations of source animals. Identifiable sources of bacteria in Cave Springs Branch at the state line were dominantly cow and horse with one ribotype from bird. *Escherichia coli* was detected in only one well sample. Bacterial ribotypes in water from that upgradient well indicated human and dog feces as sources for bacteria, and that on site wastewater treatment may not always be adequate in these highly permeable soils.

Greater concentrations of nitrate in Cave Springs Branch and O'Brien Spring relative to the poultry-processing plant wastewater outfall may be due, in part, to conversion of ammonia from poultry processing plant wastewater. The poultry-processing plant wastewater outfall sample collected in March 2000 contained greater concentrations of ammonia and total organic nitrogen plus ammonia than the spring, stream, and well samples collected during August 1999. Cave Springs Branch and Honey Creek contributed approximately equal loads of nitrogen to Honey Creek below the confluence and the greatest loads of nitrogen were introduced to Cave Springs Branch by the poultry processing plant wastewater outfall and O'Brien Spring. Nitrate concentrations in upgradient well samples ranged from 0.38 to 4.60 milligrams per liter, indicating that there are sources of ground-water nitrogen other than Cave Springs Branch, such as animal waste, fertilizer, or human waste. Nitrogen compounds in water from wells downgradient of Cave Springs Branch may be from Cave Springs Branch, fertilizers, animal waste, or human waste.

Introduction

With increased number and size of concentrated poultry operations and an associated poultry-processing plant in the Cave Springs basin and part of the Honey Creek basin, northeastern Oklahoma, and southeastern Missouri (fig.1), concern has grown about the quality of water in the streams and the underlying Ozark Plateau aquifer system. In response to this concern, the U.S. Geological Survey, in cooperation with the Oklahoma Office of the Attorney General, conducted reconnaissance hydrologic and water-quality investigations to evaluate the potential sources of bacteria and nutrient contamination

in the Cave Springs Branch basin and the underlying karstic Ozark Plateau aquifer system.

Investigation objectives were to: (1) determine the directions of ground-water flow in the Cave Springs Branch basin and whether Cave Springs Branch interacts with ground water in the Ozark Plateau aquifer system, (2) compare water quality in Cave Springs Branch with the quality of water in water from nearby wells to determine whether water from Cave Springs Branch could be contaminating nearby wells completed in the Ozark Plateaus aquifer system, and (3) determine sources of coliform bacteria and nitrate plus nitrite as nitrogen (referred to as nitrate in this report) contamination in Cave Springs Branch and water in the Honey Creek Basin.

Potential sources of bacteria and nitrate in the area include cultivated agriculture, livestock pasture, poultry production, households, and wildlife. Poultry litter from local poultry production and poultry production in adjacent basins is spread to fertilize hay fields in the Honey Creek Basin. Cattle and horses graze throughout the area and many have access to Cave Springs Branch. Treated wastewater from a poultry-processing plant in Missouri, which includes some human wastewater from plant employees, is discharged to Cave Springs Branch about 0.7 mile upstream of the state line (fig. 1). Household wastewater is disposed of on site in cesspools or septic systems, although many of the soils in the basin are not rated as suitable for onsite disposal by the U.S. Department of Agriculture (table 5, 1970). Wildlife, including deer, coyote, rabbit, turkey, and waterfowl, also are potential sources of the contamination.

Presence of fecal coliform and fecal streptococcal bacteria directly indicate fecal contamination and the potential for the presence of other pathogenic organisms in a water supply. The maximum contaminant level of total coliform bacteria in drinking water is one colony-forming unit per 100 milliliters (U.S. Environmental Protection Agency, 1996).

Nitrate in drinking water poses health risks and may indicate the presence of additional contaminants. Nitrate is derived from the natural breakdown of inorganic fertilizers, soils, and animal wastes. Nitrate concentrations greater than 3 milligrams per liter in ground water are commonly associated with agricultural land use and disposal of human wastes (Madison and Brunett, 1985). Drinking water with nitrate concentrations greater than the recommended limit of 10 milligrams per liter as nitrogen can cause methemoglobinemia ("blue-baby" syndrome) (U.S. Environmental Protection Agency, 1996).

Purpose and Scope

This report describes results of a reconnaissance investigation of the hydrology, water quality, and sources of bacteria and nutrient contamination in streams and ground water near Cave Springs Branch of Honey Creek, and Honey Creek, in Delaware County, Oklahoma, May 1999-March 2000. This report characterizes: (1) The hydrogeologic units in the region and the directions of ground- and surface-water flow with maps of water-table altitudes during greater and lower stream flow and maps showing gaining and losing reaches of the streams; (2) the quality of water with diagrams comparing differences in water chemistry and bacterial counts between streams and wells, and tables describing the distribution of fecal bacteria, antibiotic resistance in *Escherichia coli*, and ribotypes of *Escherichia coli* in the ground and surface water; and (3) indications of probable sources of bacteria and nitrate detected in the ground water.

Description of Study Area

The 34-square-mile study area is in the Ozark Plateau physiographic province. The topography is characterized by steep slopes bounding flat floodplains (fig. 2). A topographic high 70 to 100 feet above the streams divides Cave Springs Branch from Honey Creek.

The greatest amounts of precipitation in the study area occur during March through May and September through October. January, February, July, and August typically have the least precipitation. Fall 1997 and spring 1998 were unusually dry and the spring 1999 rains did not end until late June (fig. 3). Honey Creek and Cave Springs Branch generally respond rapidly to precipitation in the stream basins (fig. 3). The two streams did not rise after it rained heavily at the Mesonet site where the Oklahoma Climatological Survey measures precipitation and other weather characteristics near Jay, Oklahoma (latitude: 36° 28′ 54″ N, longitude: 94° 46′ 59″ W), possibly because those storms were localized near the Mesonet site.

Previous Investigations

Previous investigations have indicated that ground water near Cave Springs Branch and Honey Creek (fig. 1) had been contaminated by nitrate and bacteria. The State of Oklahoma Department of Environmental Quality sampled Honey Creek, Cave Springs Branch, and wells located within one-half mile of Cave Springs Branch and Honey Creek below the confluence with Cave Springs Branch in June 1996 (Jon L. Craig, Oklahoma Department of Environmental Quality, written commun., August 27, 1996). Nineteen of 28 wells yielded water with detectable total coliform bacteria. Ammonia was detected in water samples from seven wells (0.17 to 0.29 milligram per liter); five of those samples also tested positive for total coliform. Nitrate was detected in water samples from 10 wells (0.8 to 2.3 milligrams per liter), nine of which tested positive for total coliform.

Later sampling of a larger network of wells confirmed contamination of ground water by nitrate, bacteria, and arsenic. The Oklahoma Department of Environmental Quality sampled 55 wells on September 9-10, 1996, and detected bacteria and elevated nitrate concentrations. The water samples were analyzed for counts of total coliform, *Escherichia coli*, fecal coliform, and fecal streptococci bacteria, and concentrations of nitrate, and arsenic (Jon L. Craig, Oklahoma Department of Environmental Quality, written commun., September 26, 1996). Thirty-one samples tested positive for total coliform. Five of those

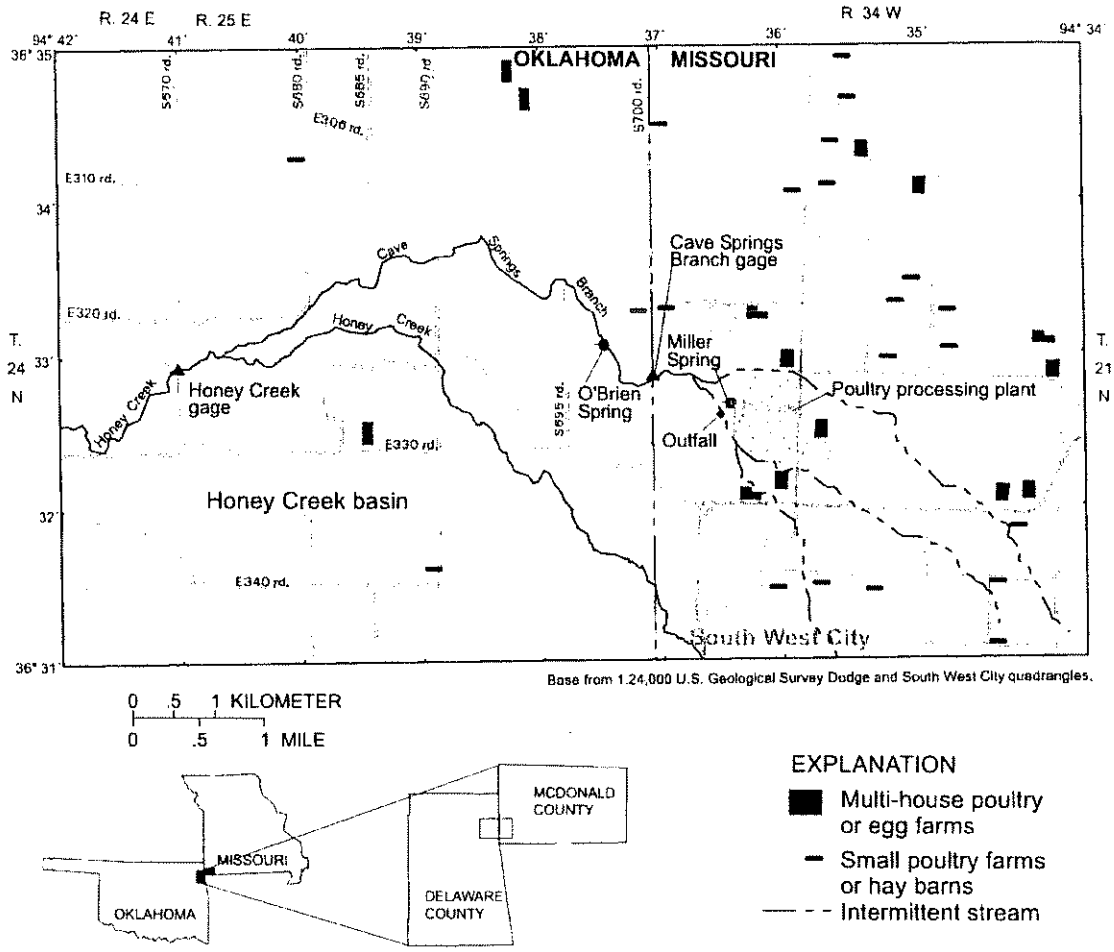


Figure 1. Location of study area.

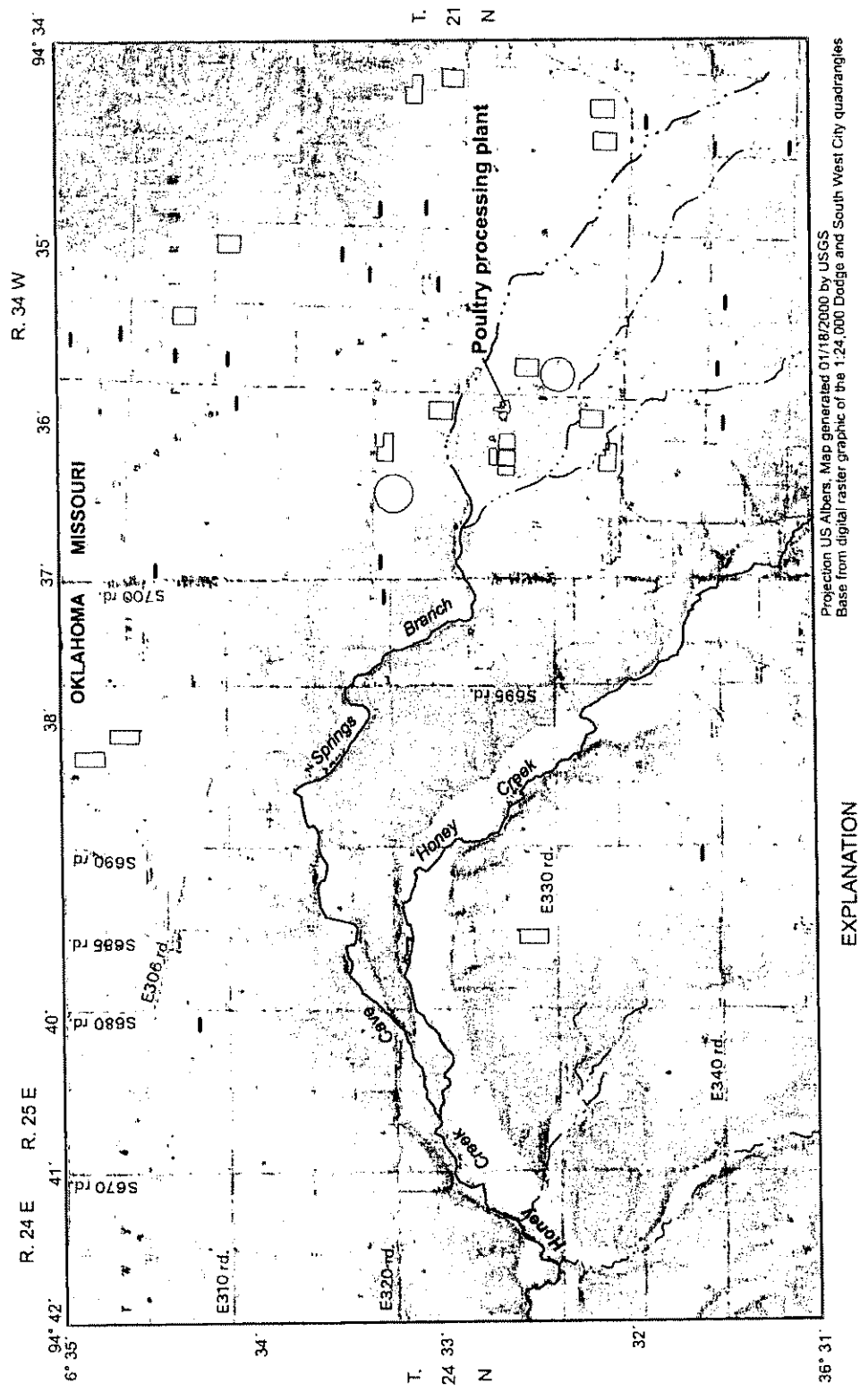


Figure 2. Topography of the study area.

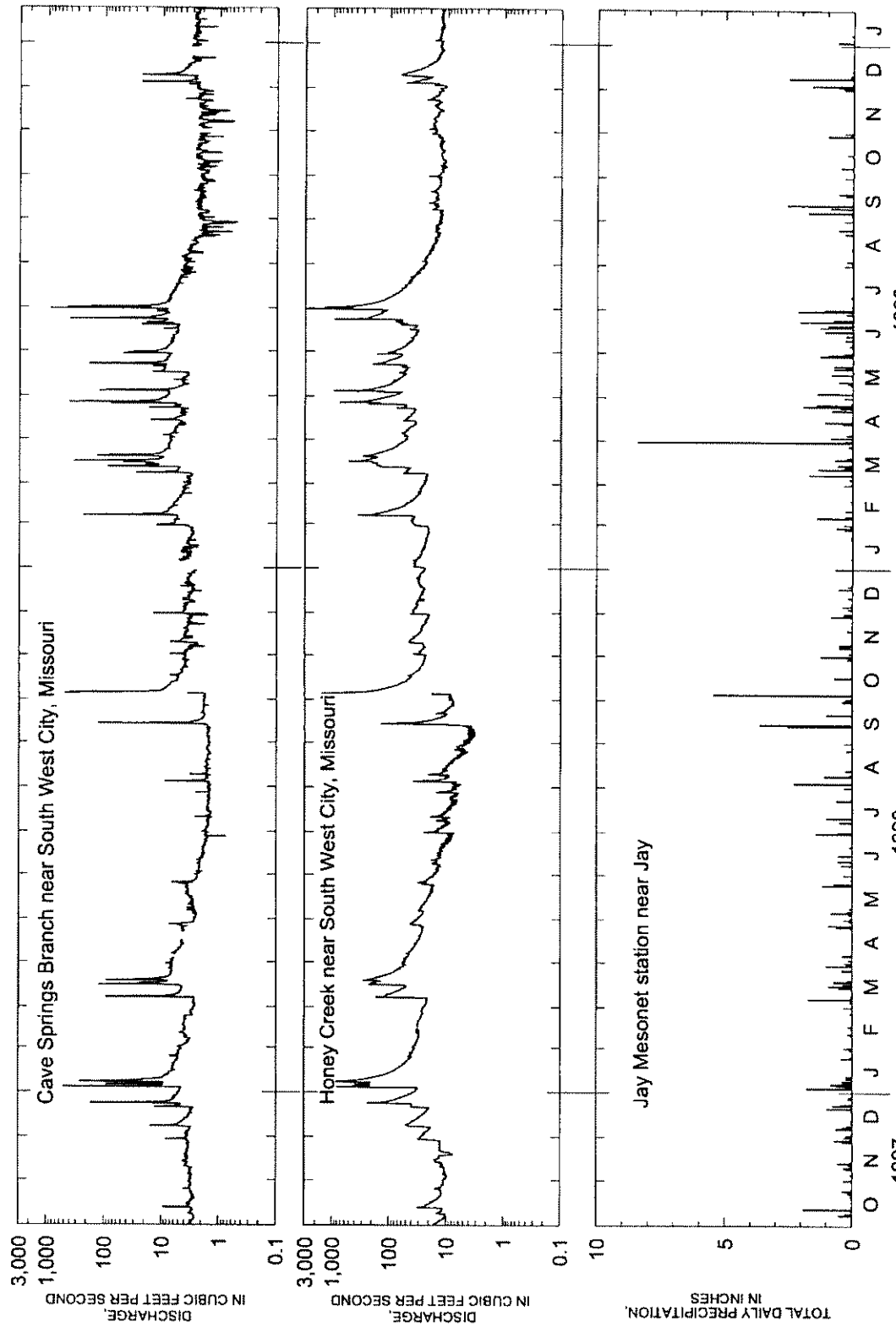


Figure 3. Total daily precipitation at the Jay Mesonet site near Jay Oklahoma, and discharge of Cave Springs Branch and Honey Creek, near South West City, Missouri.